

REMARKS

Favorable reconsideration of this application in view of the remarks to follow is respectfully requested. Since the present Response raises no new issues, and in any event, places the application in better condition for consideration on appeal, entry thereof is respectfully requested.

In the present Office Action, the drawings are objected to under 37 C.F.R. § 1.83(a) for allegedly not showing every feature recited in Claim 1 of the present application. Specifically, none of the originally filed drawings show the presence of an intermediate agent layer in the structure. In response to this formal objection, applicants have attached herewith a new Fig. 7 which includes the presence of intermediate agent layer 100. The addition of new Fig. 7 to the present application necessitated the above amendments to the specification.

Since the newly added Fig. 7 and the amendments to the specification proposed above do not introduce new matter into the specification, entry thereof is respectfully requested. Applicants observe that the submission of new Fig. 7 obviates the objection to the drawings under 37 C.F.R. § 1.83(a); therefore reconsideration and withdrawal of the drawing objection are respectfully requested.

Claims 1, 6, 9, 10, 18, 19 and 21-23 stand rejected under 35 U.S.C. § 112, first paragraph, as allegedly failing to comply with the enablement requirement and written description requirement. Specifically, there is no evidence or support in the originally filed specification that Al can be used as an intermediate agent which can be converted into a metal silicide.

In response to the formal grounds of rejection, applicants have amended Claim 1 to positively recite that the intermediate agent layer comprises a metal selected from the group consisting of W, Co Ti and any other metal that can react with silicon to form a metal silicide. Support for this amendment to Claim 1 is found at Page 7, lines 13-17 of the originally filed specification. Applicants observe that Al has been deleted as a possible metal that can be silicided during bonding.

Applicants submit that the above amendment to Claim 1 obviates the formal grounds of rejection raised in the present Office Action without adding any new matter into the specification. Entry of the amendment to Claim 1 and withdrawal of the rejections under 35 U.S.C. § 112, first paragraph, are respectfully requested.

Claims 1, 9, 10, and 19 stand rejected under 35 U.S.C. § 103 as allegedly unpatentable over the combined disclosures of U.S. Patent No. 6,521,041 to Wu, et al. ("Wu, et al."), U.S. Patent No. 6,328,796 to Kub, et al. ("Kub '796") and S. Wolf, et al. "Silicon Processing for the VLSI Era, Vol. 1-Process Technology", Lattice Press: Sunset Beach CA, 1986, pp.386-391 ("S. Wolf, et al."). Claim 6 stands rejected under 35 U.S.C. § 103 as allegedly unpatentable over the combined disclosures of Wu, et al., Kub '796, S. Wolf, et al. and U.S. Patent No. 5,906,951 to Chu, et al. ("Chu, et al."). Claims 1, 9, 10, 19 and 21-23 stand rejected under 35 U.S.C. § 103 as allegedly unpatentable over the combined disclosures of U.S. Patent No. 6,573,126 to Cheng, et al., Kub '796 and S. Wolf, et al.. Claim 22 stand rejected under 35 U.S.C. § 103 as allegedly unpatentable over the combined disclosures Cheng, et al., Kub '796, S. Wolf, et al. and U.S. Patent No. 6,153,495 to Kub, et al. ("Kub '495").

Applicants submit that the combinations of applied references that utilize Wu, et al. as the principal reference do not render applicants' claimed method obvious since none of the applied references teaches or suggests the various processing steps claimed. Specifically, the applied references do not teach or suggest a method which includes the steps of forming a graded $\text{Si}_{1-x}\text{Ge}_x$ epitaxial layer on a first single crystalline semiconductor substrate, forming a relaxed $\text{Si}_{1-y}\text{Ge}_y$ epitaxial layer over said graded $\text{Si}_{1-x}\text{Ge}_x$ layer, smoothing the surface of said relaxed $\text{Si}_{1-y}\text{Ge}_y$ epitaxial layer to provide a surface roughness in the range from about 0.3 nm to about 1 nm root mean square (RMS), selecting a structure having an upper surface and comprising a second substrate, having a surface roughness in the range from about 0.3 nm to about 1 nm RMS *and an intermediate agent layer comprising a metal selected from the group consisting of W, Co and any other metal that can react with silicon to form a metal silicide*, and bonding said smoothed surface of said relaxed $\text{Si}_{1-y}\text{Ge}_y$ epitaxial layer on said first substrate to the upper surface of said structure including said second substrate, said step of bonding including the step of annealing to form sufficiently strong bonds across the bonding interface to form a single mechanical structure, *whereby during said bonding said intermediate agent layer is converted into a metal silicide*. Hence, *in the present invention, a metal silicide forms in-situ during the bonding step*.

Wu, et al. describes a method in FIG. 10 in which a first structure including a Si substrate 1002, a $\text{SiGe}_{1-x}\text{Ge}_x$ graded layer, and a $\text{SiGe}_{1-y}\text{Ge}_y$ uniform layer is formed. A second structure including Si substrate 1010 and SiO_2 layer 1012 is provided and thereafter the uniform SiGe layer is bonded to the SiO_2 layer of the second substrate by annealing. Wu, et al. do not teach or suggest that the second structure includes an intermediate agent layer comprising one of the metals recited in Claim 1 and that upon

annealing the metal reacts with Si to form a silicide. Applicants observe that the term "silicide" does not appear anywhere in the disclosure of Wu, et al.

The above defects in Wu, et al. are not alleviated by Kub '796 since the secondary reference does not teach or suggest the claimed method recited in amended Claim 1. In particular, Kub '796 does not teach or suggest that upon bonding the intermediate agent layer is converted into a metal silicide. Kub '796 does mention that a metal or a silicide layer may be present at the bonding interface, but there are no details in the patent as to how the layer is formed. Applicants observe that at Col. 7, lines 6-15, Kob, et al. indicates that an additional layer, such as a silicide, can be provided between the two bonding surfaces. The additional layer is disclosed as being formed prior to bonding. Hence, a silicide process, including metal deposition and annealing, occurs prior to bonding. In the claimed method, the silicide forms during the bonding step not prior, as disclosed in Kub '796.

Chu, et al., which provide a method for forming strained layers on an insulator comprising the steps of: selecting a first semiconductor substrate, forming a first epitaxial graded layer of $\text{Si}_{1-y}\text{Ge}_y$ over said first semiconductor substrate where y at its upper surface is in the range from 0.2 to 0.5, forming a second relaxed layer of SiGe, forming a third p++ doped layer of SiGe, forming a fourth epitaxial strained layer selected from the group consisting of Si and SiGe, forming a fifth relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer where x is in the range from 0.2 to 0.5, forming a sixth layer of Si, selecting a second substrate having an upper layer selected from the group consisting of Si and SiO_2 thereon, bonding the upper surface of said sixth layer and said second substrate together, and removing said first substrate and said first and second layers, do not teach or suggest the claimed method

recited in amended Claim 1. In particular, Chu, et al. do not teach or suggest that upon bonding an intermediate agent layer is converted into a silicide, as indicated in applicants' sequence of processing steps recited in Claim 1. Indeed, applicants find no reference to the term silicide in the Chu, et al. disclosure.

S. Wolf, et al. discloses various candidates for metals that can be used in forming a metal silicide. The applied reference however does not teach or suggest applicants' claimed sequence of processing steps in which the metal silicide is formed in-situ during the bonding process.

Based upon the above amendments and remarks, the obviousness rejections based on Wu, et al., Kub '976 and S. Wolf, et al. or Wu, et al., Kub '976, Chu, et al. and S. Wolf, et al. have been obviated. Reconsideration and withdrawal thereof are respectfully requested.

Applicants submit that the combinations of applied references that utilize Cheng, et al. as the principal reference do not render applicants' claimed method obvious since none of the applied references teaches or suggests the various processing steps claimed. Specifically, the applied references do not teach or suggest a method which includes the steps of forming a graded $\text{Si}_{1-x}\text{Ge}_x$ epitaxial layer on a first single crystalline semiconductor substrate, forming a relaxed $\text{Si}_{1-y}\text{Ge}_y$ epitaxial layer over said graded $\text{Si}_{1-x}\text{Ge}_x$ layer, smoothing the surface of said relaxed $\text{Si}_{1-y}\text{Ge}_y$ epitaxial layer to provide a surface roughness in the range from about 0.3 nm to about 1 nm root mean square (RMS), selecting a structure having an upper surface and comprising a second substrate having a surface roughness in the range from about 0.3 nm to about 1 nm RMS *and an intermediate agent layer comprising a metal selected from the group consisting of W, Co*

and any other metal that can react with silicon to form a metal silicide, and bonding said smoothed surface of said relaxed $\text{Si}_{1-y}\text{Ge}_y$ epitaxial layer on said first substrate to the upper surface of said structure including said second substrate, said step of bonding including the step of annealing to form sufficiently strong bonds across the bonding interface to form a single mechanical structure, whereby during said bonding said intermediate agent layer is converted into a metal silicide.

Cheng, et al. provide a method for producing monocrystalline semiconductor layers. In an exemplary embodiment, a graded $\text{Si}_{1-x}\text{Ge}_x$ (x increases from 0 to y) is deposited on a first silicon substrate, followed by deposition of a relaxed $\text{Si}_{1-y}\text{Ge}_y$ layer, a thin strained $\text{Si}_{1-z}\text{Ge}_z$ layer and another relaxed $\text{Si}_{1-y}\text{Ge}_y$ layer. Hydrogen ions are then introduced into the strained $\text{Si}_{1-z}\text{Ge}_z$ layer. The relaxed $\text{Si}_{1-y}\text{Ge}_y$ layer is bonded to a second oxidized substrate. An annealing treatment splits the bonded pair at the strained Si layer, whereby the second relaxed $\text{Si}_{1-y}\text{Ge}_y$ layer remains on said second substrate. In another exemplary embodiment, a graded $\text{Si}_{1-x}\text{Ge}_x$ is deposited on a first silicon substrate, where the Ge concentration x is increased from 0 to 1. Then, a relaxed GaAs layer is deposited on the relaxed Ge buffer. As the lattice constant of GaAs is close to that of Ge, GaAs has high quality with limited dislocation defects. Hydrogen ions are introduced into the relaxed GaAs layer at the selected depth. The relaxed GaAs layer is bonded to a second oxidized substrate. An annealing treatment splits the bonded pair at the hydrogen ion rich layer, whereby the upper portion of relaxed GaAs layer remains on said second substrate.

Applicants respectfully submit that Cheng, et al. do not teach or suggest a method in which a structure including a second substrate and an intermediate agent layer is used

and that upon bonding the intermediate agent layer forms a silicide. Applicants observe that the term "silicide" does not appear in the disclosure of Cheng, et al.

The above defects in Cheng, et al. are not alleviated by S. Wolf, et al. and Kub '796 for the following reasons: S. Wolf, et al. are deficient for the reasons discussed above. The applied Kub '796 reference does not teach or suggest that upon bonding the intermediate agent layer is converted into a silicide. Kub '796 does mention that a metal or a silicide layer may be present at the bonding interface, but there are no details in patent as to how the layer is formed. Applicants again observe that the silicide is disclosed as an additional layer that is formed prior to bonding in Kub '796.

Kub '495 does not alleviate the above defects in the applied combination of references since it does not teach or suggest that upon bonding the intermediate agent layer is converted into a silicide. Kub '495 does mention a silicide layer 123 may be present at the bonding interface (see FIG 13), but the silicide is formed prior to bonding, not during bonding, as presently claimed.

Based upon the above amendments and remarks, the obviousness rejections based on Cheng, et al., S. Wolf, et al. and Kub '976 or Cheng, et al., Kub '976, S. Wolf, et al. and Kub '495 have been obviated. Reconsideration and withdrawal thereof are respectfully requested.

Thus, in view of the foregoing amendments and remarks, it is firmly believed that the present case is in condition for allowance, which action is earnestly solicited.

Respectfully submitted,



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Enclosure One (1) drawing sheet